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A COMPREHENSIVE TEST PLAN FOR THE
EVALUATION OF TELEVISION CONTRAST
AUTOMATIC TRACKERS

ARMY MISSILE RESEARCH
DEVELOPMENT AND ENGINEERING LAB.
REDSTONE ARSENAL, ALABAMA

20 DECEMBER 1976

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TECHNICAL REPORT RG-77-4

**A COMPREHENSIVE TEST PLAN FOR THE
EVALUATION OF TELEVISION CONTRAST
AUTOMATIC TRACKERS**

Michael C. Pitruzzello and Mark D. Dixon
Guidance and Control Directorate
US Army Missile Research, Development and Engineering Laboratory
US Army Missile Command
Redstone Arsenal, Alabama 35809

20 December 1976

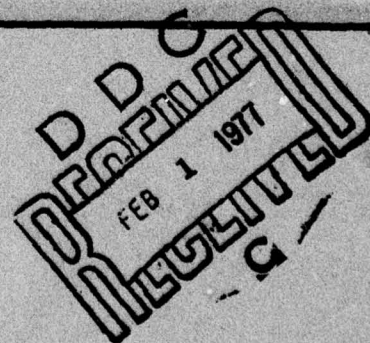
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Many types of television contrast automatic trackers are available today. However, there is no standard by which a user can compare trackers and thus choose the one best suited to the user's needs. This standardized test plan for television contrast automatic trackers will generate data to compare the performance characteristics of various trackers.		

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I. INTRODUCTION

Recently, long-range, highly accurate point target weapons such as laser-guided and television (TV) guided rockets and bombs have been developed. As a result, the requirement that the weapons system be able to accurately track the target to ensure a high first-round kill probability has also developed. In the case of laser-guided weapons, the tracking accuracy requirements are so severe that the normal means for tracking a target (i.e., manual or "human-in-the-loop" tracking) are taxed to the limit. For TV-guided bombs and rockets, a manual guidance scheme requires a video and a data link which are subject to electronic countermeasures. Thus, there is a need for an automatic target tracker which can track a target from a TV signal.

Trackers which perform the preceding task are available from various manufacturers. In general, the operator slews the TV system until the target rests within a set of "track gates" within which the tracker "looks" for a target. The operator then initiates autotracking, and the tracker is expected to track the target. Many TV contrast autotrackers currently available will not satisfactorily meet missile system requirements. The major problems with such autotrackers are:

a) The TV trackers use target-to-background contrast for tracking information. Military targets often present low ($<10\%$) target/background contrast in the spectral region where present vidicons operate, thus making autotracking difficult.

b) These trackers are subject to "break-lock" when the target becomes entirely or partially obscured by dust, trees, etc.

c) Many trackers cannot track "unbounded" targets which can occur when a target is partially hidden by a large obstruction which is of the same luminance as the target. Thus, the autotracker will not be able to distinguish at least one edge of the target from the obstruction.

It has been the experience of the authors that every currently available autotracker exhibits the preceding shortcomings to one extent or another.

A. Test Plan Objectives

This test plan is a guideline for the measurement of parameters which cause or affect the shortcomings previously noted. It was written for measurements on the tracker (as a stand alone unit) using a synthetic target video generator.¹ However, with proper

¹Pitruzzello, Michael C., Dixon, Mark D., and Moore, Leonard M., An Electronic Target Generator to Test Television Contrast Automatic Trackers, US Army Missile Command, Redstone Arsenal, Alabama, 14 August 1975, Technical Report RG-76-8.

modification, it can be used as an outline in testing the critical parameters of a total TV-tracker servosystem. A typical test setup using the synthetic target generator is shown in Figure 1.

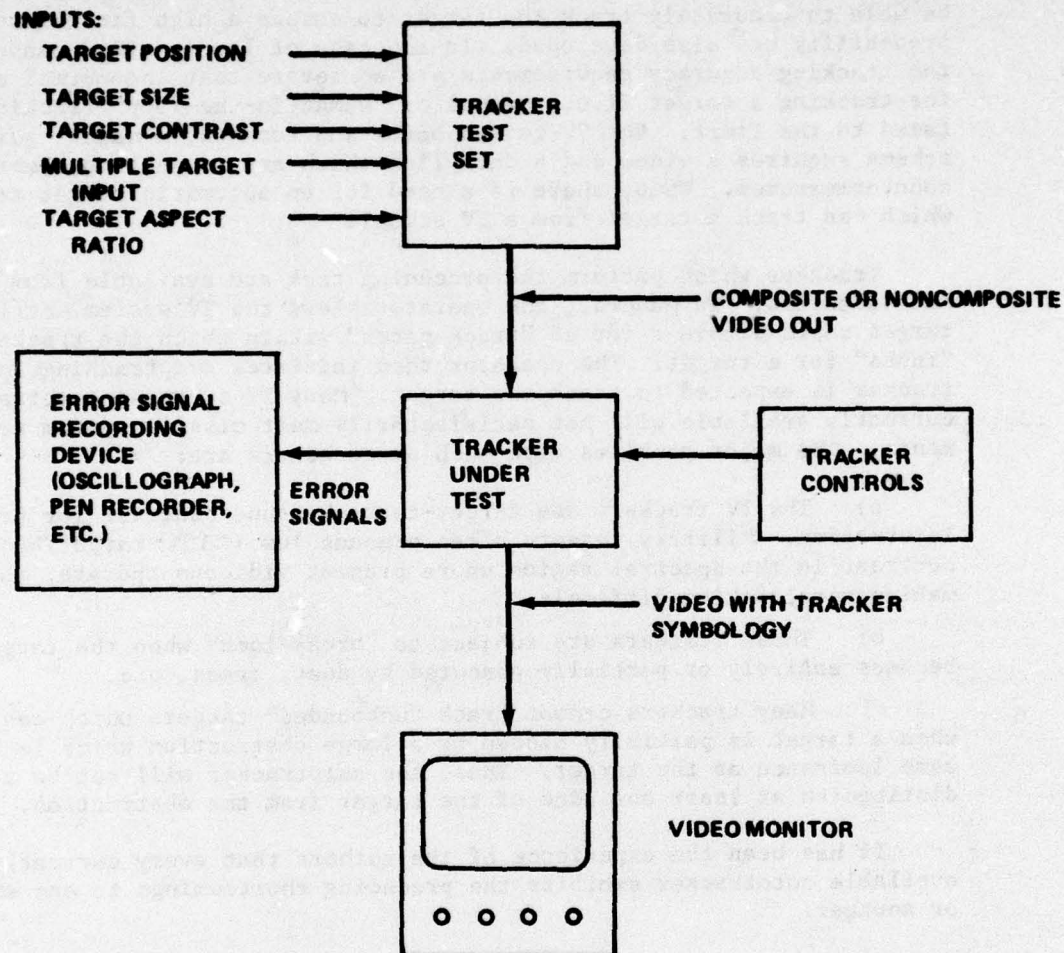


Figure 1. Typical test setup using a synthetic target generator.

B. Test Sections

A brief summary of each test section may prove helpful in providing insight as to the purpose of each test. The target lock-on tests were designed to determine the conditions under which the tracker will achieve a successful lock-on. These tests examine the ability of the tracker to accurately track very low contrast targets (of varying

sizes and shapes), lock-on to a target that is moving with respect to the aimpoint, and lock-on to certain types of unbounded targets which occur frequently in military target situations.

The break-lock tests were designed to determine the conditions under which the tracker may be expected to "lose" the target after a successful lock-on has been obtained. As in the lock-on tests, the effects of target contrast, size, and slew rate on the ability of the tracker to accurately track the target are evaluated. In addition, the ability of the tracker to track a target whose contrast is changing rapidly (such as a target moving through smoke) is evaluated. Section III.D. is probably the most important part of this test plan. The most serious problem with present day TV contrast trackers is that most of them cannot track targets past obscurations. Section III.D. presents an evaluation of the ability of the tracker to track targets which are partially obscured.

The tracking tests are designed to give the electrical output and gate characteristics of the tracker. The electrical output characteristics give an indication of tracker bandwidth and gain. The gate characteristics are given as an indication of the clutter rejection and closing rate capabilities of the tracker.

II. LOCK-ON TESTS

The object of these tests is to determine the target and background conditions under which the tracker will achieve a successful lock-on.

A. Effects of Target Size and Aspect Ratio on Target Lock-On Contrast Threshold

Target size and aspect ratio shall be independent variables. The target lock-on contrast threshold shall be the dependent variable and shall be measured in accordance with the following steps:

- 1) The tracker shall be operating (power applied) and, if applicable to the tracker under test, the target polarity switch shall be set in accordance with the polarity of the target. The target contrast shall be set initially at 2%.

- 2) The target shall be moved slowly from a position that is out of the track gates into the track gates such that the centroid of the target lies approximately in the center of the track gates.

- 3) Autotrack shall then be initiated.

4) If the tracker cannot successfully track the target, the absolute value of target contrast shall be increased 2% and steps 2), 3), and 4) repeated until the tracker can track the target. The contrast value thus obtained shall be recorded as the lock-on contrast threshold.

The following values of target size and aspect ratio shall be used.

Target aspect ratio

- 4:1 (typical tank, side view)
- 3:1 (typical armored personnel carrier, side view)
- 1:1 (armored personnel carrier, front view)

Target size values

- 5%
- 15%
- 30%
- 50%
- 80%
- 95%

Target lock-on contrast threshold measured shall be entered in the following table. Two of these tables will be made, one for "black" targets, and one for "white" targets.

Target Aspect Ratio	Target Size					
	5%	15%	30%	50%	80%	95%
4:1						
3:1						
1:1						
1:2						

B. Effects of Target Slew Rate on Lock-On Ability

Target size, aspect ratio, and contrast shall be independent variables. The maximum lock-on slew rate shall be the dependent variable and shall be measured in accordance with the following steps:

1) The tracker shall be operating (power applied) and, if applicable to the tracker under test, the target polarity switch shall be set in accordance with the polarity of the target.

2) The target shall be moved from a position outside the track gates into the track gates at a constant slew rate. When the centroid of the target lies in the center of the track gates, autotrack shall be initiated. The target motion shall be continued past the center of the track gate.

3) If the tracker successfully locks-on to the target, the target slew rate shall be increased by 2% of the field of view (FOV)/second and steps 1), 2), and 3) repeated until the tracker cannot lock-on to the target. The slew rate thus obtained shall be recorded as the maximum lock-on slew rate.

The following values of target size, aspect ratio, and contrast shall be used.

Aspect ratio

4:1
3:1
1:1
1:2

Target size values

5%
15%
30%

Target contrast values

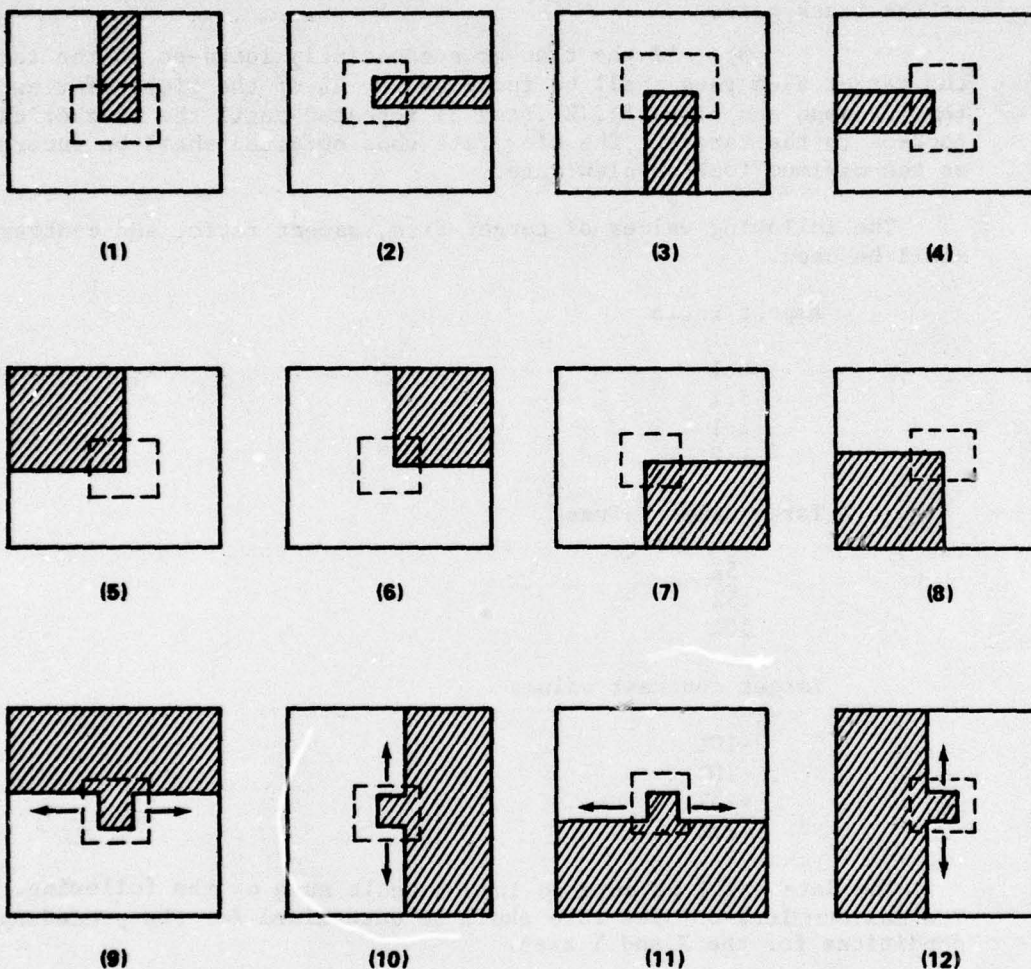
+10%
-10%
+25%
-25%

The data shall be entered into a table such as the following. The maximum lock-on slew rate shall be determined for the preceding conditions for the X and Y axes.

Target Aspect Ratio	Target Size (-10% contrast)		
	5%	15%	30%
4:1			
3:1			
1:1			
1:2			

C. Unbounded Target Tracking Test

To test the ability of the tracker to track unbounded targets, the following stationary targets will be used. (Targets are cross-hatched and track gates are dashed.)



In targets 1 through 4, the small target dimension shall be 15% of the field-of-view (FOV) and the large target dimension shall be 50% of the FOV and oriented as shown. In targets 5 through 8, the small target dimension shall be 50% of the FOV and the large target dimension shall be 50% of the FOV and oriented as shown. Targets 9 through 12 can be thought of as having a large rectangle with a small rectangle placed next to it. The large rectangle shall have dimensions of 40% of the

FOV by 100% of the FOV and oriented as shown. The small rectangle shall have dimensions of 20% of the FOV for both axes and shall be capable of movement as shown by the arrows. The small rectangle will have the same contrast as the large rectangle. In all of the target cases (1 through 12) the absolute value of target contrast shall be 15% greater than the lock-on contrast threshold measured in Section II.A.

The test shall consist of the following steps:

- 1) The tracker shall be operating (power applied) and, if applicable to the tracker under test, the target polarity switch shall be set in accordance with the polarity of the target.
- 2) The target shall be moved from a position outside the track gates into the track gates in the positions shown in targets 1 through 12.
- 3) Autotrack shall be initiated. The targets shall then be moved $\pm 5\%$ of the FOV in X and Y (except targets 9 through 12 shall be moved $\pm 5\%$ of the FOV in the direction of the arrows). The tracker error outputs shall be monitored to determine if they follow the target motion.

III. BREAK-LOCK TESTS

The purpose of these tests is to determine the target and background conditions under which the tracker may be expected to "lose" the target it is currently tracking.

A. Effects of Target Size and Aspect Ratio on Break-Lock Contrast Threshold

Target size and aspect ratio shall be independent variables. The target break-lock contrast threshold shall be the dependent variable. It shall be measured by locking-on to a target with a contrast that is easily tracked, then reducing the absolute value of the contrast until a break-lock occurs. Data shall be entered in the following table under the conditions noted. The break-lock contrast threshold shall be measured for black and white targets.

Target Aspect Ratio	Target Size					
	5%	15%	30%	50%	80%	95%
4:1						
3:1						
1:1						
1:2						

B. Effects of Target Size and Aspect Ratio on Maximum Tracking Slew Rate

Target size, aspect ratio, and contrast shall be independent variables. The maximum tracking slew rate shall be the dependent variable. It shall be measured by locking-on to a stationary target, then slowly increasing target slew rate until a break-lock occurs. This shall be done for the X and Y axes. The data shall be entered in the following tables with the conditions specified.

Target Aspect Ratio	Target Size (+10% Contrast Target)		
	5%	15%	30%
4:1			
3:1			
1:1			
1:2			

Target Aspect Ratio	Target Size (+25% Contrast Target)		
	5%	15%	30%
4:1			
3:1			
1:1			
1:2			

Target Aspect Ratio	Target Size (-10% Contrast Target)		
	5%	15%	30%
4:1			
3:1			
1:1			
1:2			

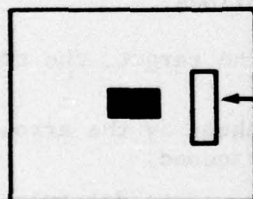
Target Aspect Ratio	Target Size (-25% Contrast Target)		
	5%	15%	30%
4:1			
3:1			
1:1			
1:2			

C. Rapid Contrast Change Test

This procedure will test the tracker's ability to adapt to rapid contrast changes such as those which occur when a target moves through smoke or dust. While autotracking a stationary target (target size = 20%, aspect ratio=1:1), the target contrast (absolute value) shall be dropped from 25% to some lower value (step change). The amplitude of this step change shall be increased until the tracker breaks lock when the step change occurs.

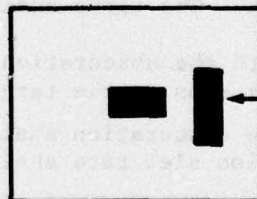
D. Obscuration of Target Test

The purpose of this test is to determine whether the tracker can successfully track targets past obscurations. The following "standard" targets will be used:



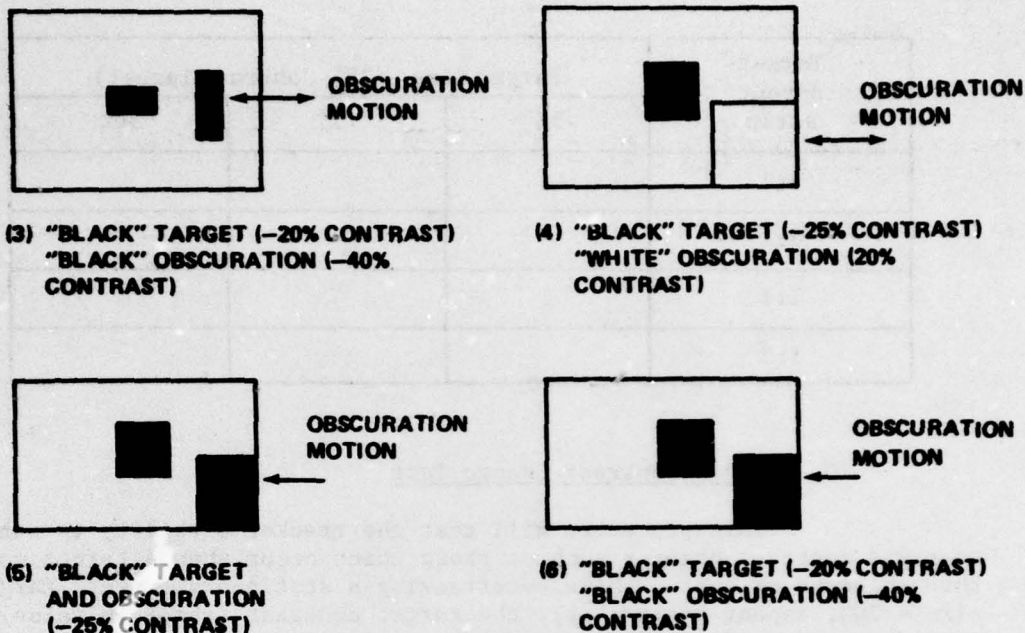
OBSCURATION
MOTION

(1) "BLACK" TARGET (-25% CONTRAST)
"WHITE" OBSCURATION (20% CONTRAST)



OBSCURATION
MOTION

(2) "BLACK" TARGET AND "BLACK"
OBSCURATION (-25% CONTRAST)



In targets 1, 2, and 3, the target size shall be 20% and the target aspect ratio shall be 2:1. The obscuration for targets 1, 2, and 3 shall have a size of 40% and an aspect ratio of 1:4. In targets 4, 5, and 6, target size shall be 20% and the aspect ratio shall be 1:1. Obscuration size for targets 4, 5, and 6 shall change from 20% to 100% in the direction shown by the arrows at a rate of 20% of the FOV/second. The obscuration height shall be such that it can obscure 50% of the target height. The tests shall be conducted as follows:

- 1) With the obscuration well removed from the target, the tracker shall be locked-on to the target.
- 2) The obscuration shall then be moved as shown by the arrows. The obscuration slew rate shall be 20% of the FOV/second.
- 3) The tracker error signals shall be monitored to determine whether the tracker is successfully tracking the target or whether it has broken lock or switched targets (i.e., begins tracking the obscuration).

The targets which can successfully be tracked shall be noted. If the tracker cannot track the target, the failure mechanism or symptoms shall be noted.

IV. TRACKING TESTS

The object of this series of tests is to determine the tracking response of the system (gain/phase and step response) and to determine the tracker gate parameters.

A. Tracker Frequency Response

The tracker frequency response (gain and phase) shall be measured using targets whose aspect ratios are 1:1, sizes are 5%, 10%, and 20%, and the target contrast shall be $\pm 25\%$.

B. Tracker Step Response

The target position shall be varied with a step input having an amplitude low enough that it does not cause the tracker to break-lock. The tracker error signals will be recorded.

C. Tracker Gain Versus Target Size Test

The tracker gain versus target size shall be measured by monitoring the tracker output signals while slowly varying the target size. The target shall be slowly moved sinusoidally in X and Y to make measurement of the tracker error signals easier. The target aspect ratio shall be 1:1, the target contrast shall be $\pm 25\%$, and the target size shall be slowly varied from 5% to 80%.

D. Track Gate Standoff Time Measurement

If the internal track gate signals are available (i.e., those signals which determine the beginning and end of the track window), these signals shall be used as timing references. The time between the leading edge of the track gate and the leading edge of the target and the time between the trailing edge of the target and the trailing edge of the track gate shall be recorded.

If the internal track gate signals are not available, the tracker symbology shall serve as the timing references.

For the preceding tests, X and Y axis gate standoff times will be recorded. The target size shall be 15%, the contrast shall be $\pm 25\%$, and the aspect ratio shall be 1:1.

E. Track Gate Expansion/Contraction Time

With the tracker tracking a stationary target (contrast = $\pm 25\%$, aspect ratio = 1:1) the target size shall be varied from 10% to 25% (step input) and the gate size change in X and Y shall be recorded. From the recorded data the gate expansion time shall be calculated by measuring the time required to expand from 10% to 90% of the size increase (Figure 2).

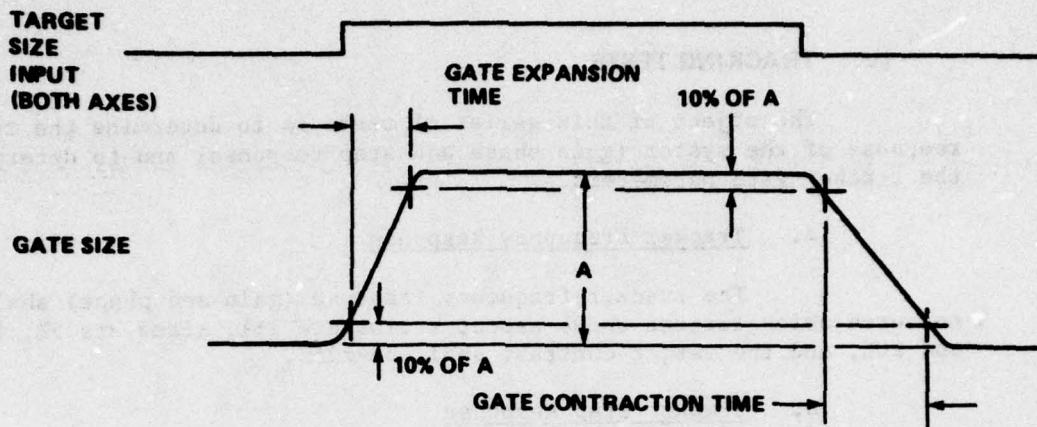


Figure 2. Gate expansion/contraction time measurement.

Appendix A. TEST PARAMETER DEFINITIONS

The following definitions apply only to homogeneous rectangular targets residing in an homogeneous background.

- 1) Target Size - The largest target dimension (% of the raster dimension).
- 2) Target Aspect Ratio - The ratio of target width to height.
- 3) Target to Background Contrast (or Target Contrast) - Defined by the following formula:

$$C_T = \frac{V_T - V_B}{V_W - V_{BL}} \times 100\%$$

where

V_T = the target voltage

V_B = background voltage

V_W = maximum white voltage

V_{BL} = video blanking voltage.

- 4) "Black" Target - If $V_T - V_B < 0$, the target is defined to be "black."
- 5) "White" Target - If $V_T - V_B > 0$, the target is defined to be "white."
- 6) Lock-On Contrast Threshold - The minimum value of the absolute value of target-to-background contrast such that a stable lock-on will occur. Mathematically, if

$$\left| \frac{V_T - V_B}{V_W - V_{BL}} \right| \times 100\% < \text{lock-on contrast threshold ,}$$

a stable lock-on will not occur.

- 7) Break-Lock

a) If the tracker contains provisions for monitoring tracking performance and issues a digital signal which indicates that the tracker is not performing satisfactorily, the issue of such a signal will define a break-lock.

b) If the tracker error signals fail to represent a reasonable approximation to the position and/or motion of the target, a break-lock has occurred.

8) Background Level - Defined by the following formula:

$$BL = \frac{V_B - V_{BL}}{V_W - V_{BL}} \times 100\% ,$$

where

V_B = background voltage

V_{BL} = video blanking voltage

V_W = maximum white voltage.

9) Break-Lock Contrast Threshold - The minimum value of the absolute value of target to background contrast below which a break-lock will occur. Mathematically, if

$$\left| \frac{V_T - V_B}{V_W - V_{BL}} \right| \times 100\% < \text{break-lock contrast threshold} ,$$

a break-lock will occur.

10) Target Slew Rate - Defined on a per-axis basis as a percentage of the raster area per second.

11) Maximum Lock-On Slew Rate - The minimum slew rate at which it is not possible for the tracker to achieve a successful lock-on.

12) Maximum Tracking Slew Rate - The maximum target slew rate at which the tracker will not break-lock.

13) Track Gate Standoff Time - The time between the beginning of the track window and the beginning of the target, or the time between the end of the target and the end of the track window.